BIOCHEMICAL
RESEARCH LABORATORY

ANNUAL REPORT
1953

THREEFOLD FARM - SPRING VALLEY, NEW YORK

BIOCHEMICAL RESEARCH LABORATORY

Threefold Farm

Spring Valley, New York

As in previous years our work was divided into various categories as follows: (a) agricultural and compost research, (b) crystallization research, (c) biochemistry of soils and agricultural products, and (d) pure basic research. It is sometimes difficult to draw the dividing line. Therefore the different phases of the work are outlined.

AGRICULTURAL AND COMPOSTING RESEARCH:

We now have an eight year survey of soil improvements on this reporter's farm at Chester, New York. All pertinent data have been published and will continue to be published in BIO-DYNAMICS. The main results of fertilizing these soils with the B. D. Compost Starter treated compost are: a reduction of acidity of all fields so that those which were originally acid are now near neutral; the organic matter content has been increased from an average below 2.0% and 3.0% to 4.0%; the crops grown on these soils are in the upper bracket of yield per acre in the area; the content of nutrients and minerals, as well as of protein, are in the upper limit for these plants in any one area. This was observed for corn, wheat, silage and hay.

The composting process with the B. D. Compost Starter has been still further perfected. We now have produced and sold considerable amounts of the Starter in a dry stable form. In this form it can be easily handled, shipped and stored. It will keep in this dry form for 6 to 9 months if stored in a cool dry place (refrigeration is not

necessary), and not exposed to direct sunlight. A great number of testimonial letters regarding the successful results obtained from the use of the Starter have been received. It appears that, with a very few exceptions, the results have been very satisfactory, which shows that a fast and successful fermentation can be achieved if the process is handled correctly. There were a few cases where the Starter did not work or the process was too slow. These exceptions did not amount to more than 0.3% of all cases where the Starter was used. It was our particular interest to study the reasons for these failures. We found them to be as follows:

(1) The piles heated up too quickly and fermentation stopped. In all these cases the piles were allowed to become too dry and moisture was not replenished fast enough.

(2) The piles remained too dry or too wet.

(3) The piles did not ferment due to insecticides or weedicides adhering to the plants used in composting. It was observed, however, that these piles when re-inoculated with the B. D. Compost Starter would ferment. The destruction of so-called economic poisons takes time. Even such stable poison as DDT will deteriorate. It has been observed that earthworms begin to attack leaves sprayed with DDT after two months.

(4) Piles containing a mixture of raw source materials low in nitrogen need to be corrected for nitrogen deficiency in order to bring the total nitrogen content up to at least 0.8% for typical fast fermentation. Otherwise fermentation will move slowly until the favorable carbon-nitrogen relationship of 20:1, optimal 11:1, is established.

(5) Sawdust piles follow a somewhat different pattern. Investigations in connection with the decomposition of sawdust are still under way.

LARGE SCALE COMPOSTING &

DEVELOPMENT OF ORGANIZATIONS:

The expansion of large scale composting projects and the signing of franchise agreements were greatly handicapped because of the cancellation of Dr. Pfeiffer's contract with the Compost Corporation of America. This company proved unable to carry out a greater program. Arbitration with this company was pending during the year and it was impossible to make any agreements or contracts during this period. The plant at Oakland, California, was closed and a considerable revenue for the Laboratory failed to materialize. Due to the successful efforts of our attorney, Mr. Andrew N. Farnese, and Judge Ferdinand Pecora, a complete release from the contract was obtained so that we are now free to go ahead. The sealed formula of the B. D. Compost Starter was returned unopened, and the complete separation from the Compost Corporation of America is now a fact. Alas, this process took many months and the final release came only in December, 1953.

This affair has not only caused a loss of cash revenue of about $5,000 but there were considerable expenses involved, such as lawyer's fees, which are not yet covered and which have been advanced by our attorney.

In the meantime the following organizations have been set up and a charter granted for them:

The Pfeiffer Foundation, 226 South 16th Street, Philadelphia 2, Pennsylvania: Dr. E. E. Pfeiffer, President; Andrew N. Farnese, Executive Director, and Peter A. Escher, Treasurer. Mr. Walter Stuber and Dr. H. A. Cheplin are members of the Board of Directors.

The Foundation is a non-profit organization and its purpose is to support research, grant schol-

arships, and aid and promote research in general. Dr. Pfeiffer has turned over to it all his rights in connection with the composting invention. The Foundation in turn will grant licenses and franchise agreements to contractors.

THE GENERAL COMPOST CORPORATION, 226 South 16th Street, Philadelphia 2, Pennsylvania: This Corporation, with Andrew N. Farnese as Executive Director, will conduct the actual business of licensing, contracting, directing, erecting and controlling the composting projects, and will set up distributorships for the B. D. Compost Starter in the future. It will issue stock in order to make possible its purpose. A prospectus is in the process of being prepared.

All this is in the development stage and has been possible only since the release already mentioned has been obtained. No revenue is forthcoming from it yet.

This new distribution of labor enables the Laboratory to continue undisturbed with pure research problems. The Laboratory from now on handles only technical and research problems, while the other two organizations handle all business, legal and engineering problems, as mentioned in our Annual Report for 1952. However, for the time being the B. D. Compost Starter is produced and shipped from the Laboratory.

AGRICULTURAL AND BIOCHEMICAL TESTING METHODS:

Soil tests, with the use of quick extraction methods, are made in order to determine the availability of minerals and organic matter and pH content. It has been found that the availability of minerals, such as potash, phosphate, exchange calcium and magnesium and the content of nitrates are a function of the microlife in the soil. The study of the relationship between

availability, organic matter and humus is important and allows a better understanding and interpretation of available mineral determination. Without the knowledge of microlife and the particular state of organic matter in a given soil, the information given by availability tests is incomplete and frequently misleading. A differentiation should be made between crude organic matter, which includes leaves, roots, straw, etc., and "digested" organic matter which leads to the formation of a stable humus. Humus actually is digested organic matter.

Composts should be analyzed not only for available minerals but also for total organic matter, total nitrogen, organic nitrogen, ammonia and nitrate nitrogen in order to arrive at a proper evaluation of its fertilizer value. In addition, tests for total phosphates, potash, etc., are made. These tests are rather expensive and time consuming but cannot be avoided if complete information is to be obtained. We believe that the approach of the Biochemical Research Laboratory is quite unique and could set a pattern for all studies of composting andhumus problems in other institutions.

Besides the chemical tests, bacteriological and fermentation tests have been worked out. For these tests no examples were known. Entirely new methods have been developed by this Laboratory. In order to determine how and why certain composts rot satisfactorily and others do not, special fermentation tests have been devised. We now test for biochemical activity. The protein, aerobic, cellulose, carbohydrate and sugar fermentation is determined in detail, quantitatively in time intervals of 2, 3, 5, 7 and 14 days. The speed of fermentation is reported as well as the measurable degree. In addition the production of ammonia, nitrite, and nitrate fermentation is

measured quantitatively. Such hindering factors as the production of hydrogen disulfide, losses of organic matter due to excessive carbon dioxide development are reported. Certain enzyme systems are observed, such as catalase (oxidation) and reductase (reduction potential). All of these factors together give a clear picture of the biological activity of any phase of composting. Since this has now been put on a quantitative basis, using the same methods and conditions various composts and procedures can be compared. The result is very enlightening. The fertilizer value of any given compost can be determined and a proper application rate for specific soils and crops can be worked out. This kind of work takes away the haphazard making of composts and puts it on a scientific, quantitative basis.

In all, about 70 fermentation studies were made, 132 bacterial tests and identifications, 161 tests for all available minerals, 210 pH tests, 21 trace mineral tests, 210 organic matter tests, 161 total nitrogen tests, 70 total phosphate and 20 total potash tests. Not all of this work has been published, but will be in the near future.

We believe that here for the first time the entire composting procedure has been put on a quantitative analytical basis. For instance, if the raw source materials and their mixture in a compost are known, the fertilizer value of the finished product and the final formula can be predetermined. Our laboratory calculations have differed with later results in the field only 0.3%, which shows the high degree of accuracy that can be obtained. Our own experimental composts as well as other commercial products are studied in this way. Figures on the subject will be published in BIO-DYNAMICS during the year.

HUMUS & A NEW APPROACH TOWARD A TESTING METHOD:

The determination of total organic matter in soil or compost by means of combustion or oxidation of carbon compounds gives only an incomplete picture. So far in most research work only the total organic matter has been reported. This does not take into account in which state of decomposition the organic matter is present. Scientific literature therefore contains information about the acid soluble, alkaline soluble or other extraction methods and mentions humic acids, etc. We have found that this brings us closer to the goal but still does not give the full answer. Spectrographic analyses of organic extraction methods have been investigated and have proved to be worth while. However, these methods again are expensive and time consuming. A simplification was sought and has been found in the application of modern chromatography methods on absorption columns and filter paper discs. The results were most interesting and gratifying. Using chromatographic methods for this purpose have not only shown a great regularity and reproducibility of results but give a great deal of important information regarding the biological quality of the sample under investigation. Bacterial action and enzyme systems can be studied. The method is simple and exacting, and after 24 hours we have a definite answer.

The method is as follows: A compost or soil suspension in aqua dest, or a specific solvent of a measured quantity is allowed to filter (by capillarity and evaporation) into a horizontally placed paper disc (Whatman #1, 15 cm. diameter). A fractional separation of the various compounds takes place. The chromatogram zones reveal the type and amount of humus and the degree of "digestion" or fermentation. Individual zones can

be cut out, redissolved and quantitatively determined in a spectrophotometer.

The results of this method are compared with all other pertinent data. Experience thus gained can "judge" a chromatogram at once and can give an astonishing amount of information in a short time. Other analytical procedures, if necessary, can then be determined for a follow up.

Another feature of this method is the isolation and determination of specific products of bacterial metabolism and fermentation so that complicated biochemical identification procedures can be simplified. All this may sound difficult but it is quite simple once one has become familiar with the problem.

COMPOSTING TESTS:

In addition to the fermentation tests already mentioned, many composting tests on a laboratory and field scale have been made. In fact, any new material which arrives is studied in this way after the preliminaries at the laboratory have been completed.

The procedure is as follows: Someone wants to know whether his particular industrial waste or garbage can be successfully and economically composted. A sample is sent to the Laboratory and the individual ingredients are studied against individual bacteria strains. A Starter containing the most suitable and successful organisms for the specific material under investigation is made up and a pilot fermentation pile (or piles) built. From time to time analyses of the pile(s) aremade and the most efficient method is selected. It is our general observation that in all materials the original nitrogen content can be preserved, and once the most favorable conditions are known, the nitrogen content

can even be increased. The average increase of nitrogen in our tests was above 70% of the original level.

One example will illustrate this. The Dano Engineering & Manufacturing Company of Copenhagen, Denmark, manufactures mechanical equipment for the maceration of garbage. The plant was visited in March. Garbage there contains a high percentage of ashes (coal ashes and others) which are toxic to bacterializing. It has now been found that this toxic effect can be counteracted if the garbage containing the ashes is mixed with 20% soil and treated with our B. D. Compost Starter. A pilot test was set up in the laboratory and it was proved that a corrected garbage mixture, treated with the Starter, was able to produce a better humus and an increase of nitrogen, while the uncorrected mixture of the Dano plant did not give similar results.

ROUTINE TESTS ON PRODUCE:

Thirty two protein analyses were made of grain, hay and silage in order to determine the feeding value of these products for some of our Bio-Dynamic farms. Due to lack of time and funds, this section of the Laboratory work was handicapped and no vitamin (A & C) tests could be made this year.

CRYSTALLIZATION TESTS AND STUDIES:

Three hundred and thirty routine tests were made. In addition a study of DDT and its influence upon human blood crystallization was made. It appears that the crystallization method lends itself to the investigation of physiological after effects of residual insecticides. For these and related problems a research program was outlined but did not get started during 1953. It is hoped that this program can be advanced in 1954. Since we

have only two crystallization cells available, not more than two tests can be made each day. Our facilities are rather limited and we see no possibility at the present time to speed up the crystallization work.

GREENHOUSE TESTS:

The study of plant roots, their growth and relationship to the environment (see Annual Report for 1953) was continued but could not be completed due to lack of funds and facilities. We have only a small makeshift greenhouse which leaks and has no heating facilities. Could we afford the erection of a suitable small house which will cost about $2,000, this work could proceed independently of the seasons. It would promise to be one of the most interesting sections of our entire research program. The intention is to study the specific and selective absorption of minerals and other plant food through the root system, and to investigate the biochemical relationship of the plant with the surrounding area of the root (rizosphere). Also tests in connection with photosynthesis have been designed for the study of how the photosynthesis of a plant can be influenced biochemically and dynamically. Here the continuation and expansion of studies with the Bio-Dynamic Preparations are planned. Years ago this writer observed that the photosynthesis in sunflower leaves (chlorophyl content) could be increased and speeded up by the use of bacterial Preparation #501.

It is this kind of growth test under exact and controlled conditions which we hope to make in the greenhouse, the stimulation of chlorophyl production in leaves, stimulation of root growth and absorption by means of other Bio-Dynamic Preparations, comparing these with humus and mineral influences, and study of the organic

system which leads to the formation of vitamins or other active principles in the plant.

COMPOST & BIOLOGICAL ENGINEERING:

Various composting equipment, machines, etc., were studied in Denmark, France and Italy last spring. This department proved to be quite expensive but the results enabled us to come forth with an entirely new process for the composting of garbage and industrial wastes, especially for the mechanical handling which is far superior and more economical than that used at the Oakland plant. The new principles and procedures were worked out and tried in the Laboratory and in field tests, and blueprints were prepared. This phase of the work, it is hoped, will be taken over by the General Compost Corporation.

LABORATORY TESTING SERVICE:

That the Laboratory has complete equipment and skilled personnel for soil testing, compost and manure analysis may not be familiar to many of our members and friends. These services also include the investigation of composting processes, study of the suitability of any organic material or wastes for composting, the working out of compost formulas and fertilizer determination for each individual field, as well as analysis for deficiencies in crops, nutritional value of crops, and the protein and vitamin A and C determination. These services are available to all and we invite those interested to make use of them. For this purpose we are including with this report a page of instructions for taking soil samples and our service charges. All members of the Bio-Dynamic Farming and Gardening Association will receive a 10% discount on these charges from now on.

There are of course other institutions which make soil tests. Our strength is in the fact that

we can interpret all resultant figures, even of the mineral availability tests, on the background of the organic process in the soil. This includes not only the total organic matter, but an evaluation of the mineral-organic relationship, and if desired, of the active microlife in a given soil sample. The building up of a fertile soil, or the breakdown of an exhausted soil can be more easily understood if all these factors are integrated.

Likewise in the field of compost and manure application and in the manufacturing of compost, our tests give alead to the proper understanding of the organic process in its widest forms of application. We have found, for instance, that not all that is called compost is really compost or humus. There are as many types of compost as there are mineral fertilizers. Knowledge of the exact amount of plant food (NPK, lime, trace minerals, organic matter) which is supplied to a soil in pounds per acre is of utmost importance if disappointments or, as it sometimes happens, unnecessary overdosage, are to be avoided. The most economical and beneficial use of composts and organic fertilizers can be worked out as a result of a comparison between the needs of the crop, the soil test and the proper application of manures, composts and fertilizers. It is here that the Laboratory can be of great help to our friends. We should like to have you make use of our services for your specific situation to a much greater degree than in the past.

LABORATORY FINANCES:

This is more or less a delicate and difficult subject to present. Unfortunately the Laboratory as a research organization cannot be entirely self supporting, which is the case in most research institutions. Some income is derived from the testing service and from research done on a

"contract" basis, and some will be forthcoming from royalties on processes developed, but which have not yet been realized. Present income covers only half of current expenses. Donations during the past year reached a total of $2,918.96 which is an all time low. All friends who have contributed in a small and large way have our grateful thanks for their support and goodwill. However, the donations did not help cover the composting development expenses, nor did our financial situation permit any expansion during the year, and many important tasks remained undone.

Many tests are made of necessity for the sake of information and pure science (knowledge). Many questions and requests for general information are answered. For this informatory service the combined expenses for postage and telephone alone amounted to a little over $900. Inquiries and interest come from all areas of the United States and from far parts of the world. However, due to lack of funds and a limited staff, we cannot expand our activities to meet these demands. It is our hope that we may be able to do so as time goes on.

In order to maintain and carry on the laboratory research, we are making an appeal to our members and friends to continue their financial support, which is particularly needed at this time. All contributions are tax exempt since the Laboratory is a subsidiary of the Bio-Dynamic Farming and Gardening Association, which is a non-profit educational organization and all contributions and bequests made to it are deductible from income taxes. Kindly make checks payable to the Bio-Dynamic Farming & Gardening Association. Membership dues and subscriptions to BIO-DYNAMICS cover administration and other expenses of the Association but do not aid the Laboratory.

The Laboratory expenses for the past year were limited to $7,600, which is very low for the kind and amount of work accomplished. In order to continue biological research on plants, vitamin content in relationship to soil and its humus content and the study of root growth, as outlined for the coming year, our research budget for 1954 will be $10,000. This does not include the compost development. In order to meet this budget it has been suggested that local groups form committees to act as sponsors in helping to finance as well as increase interest in our work. Both individual and group aid will be most welcome and deeply appreciated.

I wish to express my personal thanks to all those who have stood by us and supported our efforts through our struggling years. I also wish to express my gratitude to the Threefold Farm Group for their cooperation and especially for the fact that they have allowed us for another year to be the "guest" who stayed on without paying rent. The Laboratory occupies seven large rooms in the new auditorium as well as a workshed, auxiliary greenhouse and land for field tests. Were it not for their hospitality, I would not know how to continue this work. I also wish to express gratitude to Andrew N. Farnese, Esq., who made the trip to Europe possible and accompanied the writer, and who has supported our work in a great many ways, relieving me of many legal and business problems. My gratitude also goes to the staff, which is the same as that of last year, all of whom have done painstaking work with little remuneration.

E. E. Pfeiffer

3/31/54

BIOCHEMICAL RESEARCH LABORATORY
Threefold Farm
Spring Valley, New York

Director, Dr. E. E. Pfeiffer

SOIL TESTING SERVICE, INTERPRETATION OF ANALYSIS

In order to apply fertilizer elements, compost and manures skillfully and economically as well as avoid deficiencies or overcome them, it is necessary to know your soil.

This Laboratory has made soil studies for many years. It has given special attention to the role which organic matter and humus play in connection with the major trace minerals in soil. The degree of availability, the reserves of essential minerals, of nitrogen, whether nitrate, nitrite, ammonia or organic nitrogen, in cooperation with the microlife and biological activity of a soil, decide the fertility of a field, lawn, orchard or garden.

If you want to apply fertilizers, compost and/or manure efficiently and not wastefully or in insufficient quantities, you should first take an inventory of the situation.

A general survey will contain the following information:

pH: This is the degree of acidity, alkalinity or neutral reaction. A pH of 7.0 is neutral; 6.0 to 6.8, slightly acid; 5.5 to 6.0, moderately acid; below 5.5, very acid and not suitable for most cultivated crops, except acid loving plants. Above 7.0 a soil is alkaline. Legumes prefer 6.0 and over and will not thrive in acid soils.

Available Potash: Findings indicate that 100 to 120 lbs. per acre are very low; 140 to 160 lbs. per acre, low; 180 to 220 lbs. per acre, medium; 260 to 300 lbs. per acre, high; 340 to 400 lbs. per acre, very high.

While this is correct for soils low in organic matter, it has frequently been observed that soils high in organic matter (above 2.0%) show a rating of available potash but contain no potash deficiencies. Here part of the potash is locked up together with the organic matter but still available to plant roots, and can be mobilized by bacterial action. If the microlife in the soil is low, there is an absolute deficiency even though there might be a high organic matter content. This Laboratory has specialized in testing methods to determine the answer to this question. Only the bringing together of availability, organic matter and bacterial biological activity can give the full answer in such cases.

Calcium (lime): The figures of experience show that 200 lbs. per acre are very low; 500 lbs. per acre, low; 1,000 to 1,500 lbs. per acre, medium; 2,000 lbs. per acre, high; 4,000 lbs. per acre, very high. Calcium is here described as that fraction which is present in the form of calcium carbonate (lime), that is, as exchangeable calcium, or in proper scientific

terms, ready for ion exchange. Findings of calcium should always be interpreted on the background of pH soil reaction. Liming is recommended for neutralizing acid soils. On neutral and alkaline soils the improvement of the organic state and biological activity may activate locked up calcium and no liming is necessary. Excessive liming, especially of neutral and alkaline soils can lock up and render calcium completely unavailable, and can do more harm than good.

Again, a soil with a high percentage of organic matter and favorable reaction may need less lime than the chemical formula requires. Excessive and unnecessary liming also can upset the trace mineral balance. On the other hand, liming can enhance certain trace minerals.

Magnesium: The tests made determine the availability of magnesium carbonate. Different testing methods give quite different figures, due to the kind of soil extraction method used. For our method the following values apply:

4 lbs. per acre, very low; 10 lbs. per acre, low; 40 lbs. per acre, medium; 80 lbs. per acre, high; 120 lbs. per acre, very high.

What has been said about calcium applies here too. Magnesium and calcium should be present in a certain balance. The ideal magnesium content is one third of that of calcium. The soils in the eastern section of the United States do not come anywhere near reaching this balance. In the western sections the situation is much better. It is for the almost universal magnesium deficiency in the east that we recommend the use of dolomitic limestone (a mixture of roughly two kinds of calcium with one third magnesium), rather than the use of mere "limestone". Also the magnesium makes the calcium more available and aids in avoiding calcium damage.

Nitrates (NO_3): Nitrates are a result of nitrification and nitrogen fixing bacteria in soils. The finding of nitrates does not indicate the absolute content of nitrogen, however. It tells only how much nitrogen has been transformed into nitrates. Organic matter contains a certain amount of organic nitrogen which can be made available by bacterial action in soils which are not too acid (not below pH 5.8 to 6.0). In fact when the organic matter is better than 2.0% and the bacterial life is high, 5.0% of the organic matter is in the form of organic nitrogen. Since 2.0% organic matter equals 40,000 lbs. per acre, the organic nitrogen reserve is 2,000 lbs. per acre. However, we have found that this reserve is not mobilized if the organic matter content is below 1.0%. The critical borderline for organic matter content is 1.5%.

Nitrates below 4 lbs. per acre are low; 8 to 12 lbs. per acre, medium; 24 lbs. per acre, high; 32 lbs. per acre, very high.

In using the Bio-Dynamic method and a conservative crop rotation with legumes, it is not unusual to obtain from 40 to 68 lbs. per acre. Samples taken during a summer drought or in

the spring are usually lower in nitrates than samples taken in the fall from a well maintained soil, due to seasonal peaks and lows of nitrate forming bacteria.

Ammonia (NH_3): Ammonia usually shows up after ammonia fertilization, after manuring and under such circumstances when there is too high an activity of ammonifying bacteria. Such findings would not indicate an absolute high content of nitrogen even though the findings of ammonia may be high. On the other hand, a low ammonia content may not indicate a nitrogen deficiency.

In otherwise well balanced soils high in organic matter it is not desirable to have a high ammonia content. Low ammonia findings in this case would be perfectly all right, while high ammonia findings would lead to losses. It is believed that only that amount of ammonia should be present which can be used by the plant roots immediately.

Ammonia values are: 5 lbs. per acre, very low; 10 lbs. per acre, low; 40 lbs. per acre, medium; 100 lbs. per acre, high; 200 lbs. per acre, very high. High and very high values occur rarely if ever and will indicate - as medium values do - the presence of fresh manure and/or fertilizer containing ammonia.

Phosphates (P_2O_5): Available phosphates are reported. The absolute content of phosphates can be determined only by complicated and expensive tests. If a soil is acid or very acid, the available phosphate fraction is about all there is in that particular soil. In neutral well limed and alkaline soils, a large phosphate storage may exist which does not show up in the analysis. The more neutral a soil is and the higher the organic matter content, the more of this storage can take place. We also speak of "locked up" phosphates in such soils. Microbiological activity can improve such a locked up condition.

Phosphate values are: 25 to 50 lbs. per acre, low; 75 to 100 lbs. per acre, medium; 150 lbs. per acre, high; 200 lbs. per acre, very high.

Manganese: This is a typical trace mineral and is used as a basis of judgment for the presence of other trace minerals. The findings are reported only as "trace" low, medium, high or very high. However, most soils in the eastern part of the United States are low in manganese. A low finding may be sufficient. A very high finding (this is the nature of trace minerals) may cause a toxic effect. When manganese is absent, it can be assumed that other trace minerals are also deficient.

Sulphates, Chlorides and Nitrites: If these are free and available it means losses. Sulphates, especially in connection with acid soils, mean unfavorable conditions frequently due to poor drainage. The absence of these factors therefore is favorable.

Sulphate values are: 100 to 200 lbs. per acre, low; 500 to 1,000 lbs. per acre, medium; 2,000 per acre, high. Medium and high values, according to our observations, are rare.

Chloride content in acid soils is unfavorable. Near the seashore the soil contains larger amounts of chlorides. Since plants there have adjusted themselves to wind blown chlorides from the sea air, the borderline of toxic values is somewhat higher. Chloride seepage from salt water into the ground water is definitely a disadvantage. For irrigation purposes water should be analysed for chloride content since frequent irrigation with water containing chloride will gradually accumulate chlorides in the soil and lead to damages.

Chloride values are: 100 lbs. per acre, very low; 200 lbs. per acre, low; 500 lbs. per acre, medium; 2,000 per acre, high. However, 200 lbs. per acre would already be considered toxic.

Boron: This is a typical trace mineral especially important for the growth of legumes such as alfalfa. The figures are given in parts per million (ppm): 10 ppm., low; 20 ppm., moderate and desirable; 30 ppm., high and considered toxic.

Copper: Another trace mineral. Figures are given in ppm.: 2 ppm., low, 5 ppm., medium; 10 ppm., high. High concentrations are toxic.

Zinc: The same is true for zinc. 2 ppm., low; 10 ppm., medium; 25 ppm., high. Zinc is frequently not found in soil analyses but is detectable in leaf analyses. Very little of it is needed. Orchards and especially citrus soils should be provided with zinc. Its role for field crops has not yet been established.

Iron: A high content of iron is toxic. Very little is needed. Muck soils are frequently high in iron and not suitable for garden crops. We use a grading scale from 1 to 10 for iron, 1 being low, 3 to 6 medium, and above 6, high or too high.

Spectrographic Estimate of Trace Minerals: This test is made with a spectrograph which allows a semi-quantitative estimate of the following minerals: barium, calcium, copper, iron, lead, lithium, magnesium, nickel, potassium, silver, sodium, tin and zinc. The test can be made with soils, plant tissues, seeds and composts, as well as manures. The intensity of the typical spectral lines allows an estimate of the amount of minerals present in the sample. While the other tests allow a strictly quantitative determination, this test gives only the magnitude of the presence of any mineral as follows: 1.0% to 10.0%, very strong; 0.1 % to 1.0%, strong; 0.01% to 0.1% medium; 0.001% to 0.01%, faint, below 0.001%, faint trace. For comparison, 0.001% equals 1 ppm.

This test gives a quick orientation in connection with trace minerals where other chemical quantitative analyses would be very expensive and time consuming. Barium, lead, tin and nickel are occasionally found. Their roles in plant nutrition and in soils are not established. All the above trace minerals can be found in plant tissues.

Organic Matter: The total organic matter content is reported in percent of the sample. The analysis is made by combustion and therefore reports all organic matter. It is important that no roots, leaves, stems, straw, etc., are contained in the sample. We remove all visible parts of these materials prior to the analysis. Not all "organic matter" is digested humus. To determine the digested humus is a complicated and expensive procedure and is done only upon request or for research purposes. According to our concept and experience, an organic matter content of 2.0% is good; 1.5%, critical level; and below 1.2% there is definite organic matter deficiency. 4.0% would be high and 6.0% would be very high.

However, a high percentage should be supported by a slightly acid or neutral reaction. Acid humus, especially if the pH is below 5.8, is a handicap and does not provide all the beneficial properties claimed for humus and which are expected of a good soil. Acid humus is due to poor drainage and/or anaerobic conditions, that is, poor cultivation. Muck and peat soils belong to an entirely different classification and may run up to 80.0% organic matter (on a dry basis), but this organic matter is frequently inert.

Microbiology: Aerobic bacteria are counted by soil extraction and cultures on beef-agar-peptone plates, incubation at 29° for 48 hours, in our routine method. Since counting methods are different, the figures of our test are comparable only to those obtained by the same method. Of course only such organisms will show which grow under these specific conditions. The result is exposed in millions per gram of sample.

A count of 80 million is low and indicates a poor soil. A count of 250 to 350 million is average. The best black humus soils and virgin prairie soils have a count of 500 to 700 million. Composts may reach a count much higher, 1 to 10 billion. In the older literature much lower figures are quoted, but this may be due to other counting methods.

Anaerobic Bacteria: These are grown on a medium with the exclusion of air on so-called Brewer's plates, using thioglycollate medium. Counts of 1 to 10 million are low and 50 million or more we would consider high. A low count is preferable because it indicates a well aerated soil. Waterlogged soils, soils in a poor state of cultivation, and sludge may run high.

Number of Species: Counting plates permit the separation of colonies under certain circumstances. A preliminary identification of the type of organism is possible and will in general allow an orientation of the trend of microlife in any given soil sample. The count alone, though interesting, is not sufficient and the determination of the number of species is important. The count may be high, but may consist only of one, two, three or four organisms unimportant for the humus building process, for instance, the presence of coli after the application of manure. Below 7 species we consider low; 12 to 14 species, good.

The important class of soil-humus building actinomycetes can be easily recognized. We express our findings in percent of colonies of actinomycetes as against all aerobic organisms found. 4% to 6% is a good average; 10% very good.

It is more difficult to isolate nitrogen fixing bacteria. Since they are not present in acid soils and soils low in organic matter, we look for them only in specific cases as a special research problem.

In specific cases fermentation and other methods can also be used. For practical field work with soils this is not necessary. For compost studies these methods have to be used and the analytical procedure is quite different from that of soil testing.

The tests so far reported are designed to be accessible to every farmer and gardener, and within the price range each can afford. There are many other methods which can be used for a thorough and scientific investigation, but they are expensive. However, if there is a special request and need for any of them, we can make such tests upon agreement.

One of these tests may be mentioned here: a sedimentation test in order to determine the physical structure of the soil. This is of importance in connection with difficult clay soils. If such soil is used as an addition to compost, the knowledge of the physical structure, agglutination and conglomeration may become very important.

****

IMPORTANT NOTICE

THE REPORT SHEET OF YOUR SAMPLE CONTAINS YOUR SPECIFIC ANALYSIS AND RECOMMENDATIONS. EVERYTHING IN THIS ORIENTING PAPER PERTAINING TO YOUR CASE IS UNDERLINED IN COLOR.

E. E. Pfeiffer, Director
BIOCHEMICAL RESEARCH LABORATORY

4/54

BIOCHEMICAL RESEARCH LABORATORY
Spring Valley, New York

INSTRUCTIONS FOR TAKING SOIL SAMPLES

1. SURFACE SOIL:

For practical purposes it is sufficient to have a mixed sample from each field or lot. This gives a general picture of the field in question, and is done in the following way:

Select five typical spots in the field, not too near the border, hedgerows, trees or ditches. Dig a small hole about 4 to 8 inches deep, but not into the subsoil, that is, not into the layer where there is a definite change of color. Do not use the top inch of soil. Clear away grass, stubble, moss, algae, manure or compost before digging the hole. Take ½ lb. of soil from this hole, carefully trying to get a fraction of each layer. Also include soil from hardpan, if any. If there are any lumps, add a few of these lumps to the final sample. Take all the samples obtained from the five spots in the field and mix them together thoroughly. Of this mixture, send ½ to 1 lb. Put samples in a solid, waterproof container, not in paper bags. Mark each sample on the outside of the container and put an identification slip inside. (Sometimes samples have arrived in broken paper bags, or the number tags have fallen off or have been lost, etc.; also the slips inside are often not readable by the time they arrive if there was moisture in the samples when shipped).

Instead of digging holes, a soil sampling tube or auger can be used.

Do not take samples when the soil is soaking wet.

Do not take samples right after manure or fertilizer has been applied. Allow at least four weeks for such a field to settle. If you "must" send a sample from a recently fertilized field, please mention the kind and amount per acre of fertilizer, manure or compost which has been applied. Lumps of lime, fertilizer, stones or gravel should be removed before shipping.

Mark on the sample whether it is a mixed sample or a specific one.

If a field is very irregular, for instance a high knoll with shallow soil at one end and deep moist soil at the other, it is better to send two separate samples.

If a field bears good crops in one section and fails in another, take separate samples of each section. The poor spot is the one of most interest. Note the depth of the topsoil and report history of the field with a view to crop rotation, manure, compost and/or fertilizer and type of cultivation. This will help make our report more to the point. Note also, whether a field is well or poorly drained, lasts well through a drought, is bottom land or on a slope.

For a quick survey of a farm, it is recommended that a sample be sent from the best field, the poorest field and one which is considered average. Old

pastures, however, are not representative of the general farm situation. These should be treated separately. Report the stand of clover on pastures and hayfields, or whether clover or alfalfa lasts well or is beginning to run out. When taking samples from pastures or lawns, discard the top layer with the root felt.

2. SUBSOIL:

It is not always necessary to analyze the subsoil, but it is always helpful to know the type of subsoil. Therefore, by all means report the depth of the subsoil, that is, the depth at which a distinct change in color and structure begins. Also report this color and whether the subsoil is hard or soft, stony, gravelly, sandy or clay. If you want to take subsoil samples, dig holes as described for the surface soil and dig down far enough to be within the typical color change. Go about 4 to 6 inches into the subsoil and mix samples as described above. Send about 5 ounces of each subsoil sample.

Subsoil samples are important for the following reasons: (a) if drainage problems exist; (b) if the surface soil is exposed to much drought and/or erosion; (c) if any abnormal structure and growth are observed. On arid land or "old" fields long out of cultivation, the subsoil may contain a higher fraction of minerals which have been washed down.

Any report regarding typical or prevalent weeds growing on a field will also help in classifying the soil type.

SOIL SAMPLES FROM ORCHARDS, PARKS, FORESTS, SHRUBBERIES, ETC.:

A sample taken close to the trunks of trees is not representative. Especially if the fertilizer requirements or deficiencies are to be determined it is better to take the sample from under the crown drip of the tree or shrub, that is, at least 2 to 3 feet from the trunk or main stem and near the periphery.

TIME OF TAKING SAMPLES:

The best time for sampling is in spring when the cultivation starts and after the frost in northern climates has left the ground.

Another good time is late summer or fall. These samples indicate the amount of nutrients left after the harvest.

Samples taken in spring indicate what should be done immediately for coming crops. Fall samples indicate how to prepare for the next year.

Samples taken during a prolonged drought in summer show less availability of minerals and less biological activity and are therefore less typical.

Samples should not be taken directly after a heavy rainfall or melting snow. Wait until you can walk over the field with no lumps of soil clinging to your shoes.

BIOCHEMICAL RESEARCH LABORATORY
Spring Valley, New York

SERVICE CHARGES - NEW PRICE LIST, 1954

Please check which test you want, or order by number

Soil Analysis: mineral nutriments and organic matter.

___1.	Test for available minerals, acidity	$ 2.50
___2.	Test for organic matter	1.00
___3.	Test for trace minerals (iron, zinc, boron, copper)	1.50
___4.	Tests #1, #2 & #3 combined in same sample	4.50
___5.	Spectrographic estimate of trace minerals	3.00

Soil Analysis: microbiology and soil life.

___6.	Bacteria count of soil sample	3.00
___7.	Description of species of major bacteria	3.50
___8.	Tests #6 and #7 combined	6.00
___9.	Mineral and biological tests of soil combined (#1, #2, #3, #6 & #7)	10.00

Plant Tissue Analysis: for deficiencies.

___10.	(Mail only fresh leaves, stems and other parts)	3.50

Compost and Manure Analysis:

___11.	Content of organic matter, moisture and inorganic matter	3.00
___12.	Total nitrogen (quantitative official AOAC method)	5.00
___13.	Total phosphates(" " " ")	5.50
___14.	Total potassium (" " " ")	5.50
___15.	Tests #11, #12, #13 & #14 combined	17.00
___16.	Complete manure or compost analysis, (official methods) containing total nitrogen, phosphates and potash, organic matter, moisture; available phosphates, potassium, ammonia, nitrate	21.00
___17.	Bacteriological analysis of compost and fermentation test	15.00
___18.	Tests #16 & #17 combined	34.00

Test #16 gives the fertilizer value of the compost or manure, how much per acre to be applied, etc.
Test #17 gives the fermentation process present in the compost sample.

___19.	Compost fermentation tests in order to study the suitability of organic materials	upon agreement
___20.	Protein test of leaves, seeds, crops, silage	7.00
___21.	Vitamin A (carotene) test of leaves, seeds, fruits	7.00

Special research problems can be done upon agreement

Members of the Bio-Dynamic Farming & Gardening Association receive a 10% discount on all above prices.

Mail samples to: Biochemical Research Laboratory
Threefold Farm, Spring Valley, New York

Name_____ Date_____

Address_____
(Street) (City) (State)